OPERATION RESEARCH

using Julia

PART 1

Operation Research is the methodology used in many companies to solve complex mathematical problems like revenue, schedule, and routing. The main concept in the study and methodology is to develop a model that contains algorithms to solve the unique problem of the company. Most models developed are designed with an objective to Maximize or Minimize the product or process. This is a high-level overview of the main process of developing models with the given constraints, variables, parameters, and objectives. The reader must have a background in programming and Linear Algebra.

Note: Using Julia, because has been constructed to solve optimization and machine learning problems.

OPTIMIZATION

Optimization is the process of maximizing or minimizing the objective function $f(\chi)$. It is the process of getting the best possible outcome of the objective.

$$\max f(x)$$

$$\min f(x)$$

examples:

1. *maximize the revenue of the company*
2. *minimize distance from point A to point D.*

CONSTRAINTS

Constraints are limitations that have to be considered when optimizing the objective function $f(\chi)$. Most objective functions are going to have multiple and complex constraints that have to be identified only by having a good understanding of the business concept. We say that the objective function is maximized or minimized only "*subject to (s.t.)*" the constraints.

example:

You are taking a trip from point A to point D but you want to minimize the distance from point A to point D. Along the way, you know the pets have to stop for a break at point B and the family wants to take scenic pictures at point C.

min Distance (A to C)	*Objective*
passing in B	*Constraint 1*
passing in C	*Constraint 2*

VARIABLES

Variables are unknown before the optimization problem. They are the decisions or what is defined by the optimization process. Variables can be derived, presented, or resolved as continuous, integer, or binary.

CONTINUOUS	*INTEGER*	*BINARY*
all values	*whole values*	*zero or one*

example: Wish to maximize the revenue of the company by changing the price. You do not know the optimal price that would maximize revenue. In this case, price is a variable and can be a continuous integer, binary variable, or continuous variable.

PARAMETERS

The parameter is a known, defined, and normally fixed value before the optimization problem. In all mathematical problems, parameters must exist, otherwise, the problem will be unsolvable.

examples: Wish to maximize the production of a product. The cost of production of each variable is known. Therefore, the cost of production of each variable is a parameter and each product cost can be differentiated in the model. Producing product 1 (p1) and product 2 (p2); one hour is required to produce p1 and 3 hours to produce p2, however, the limited labor hours is 1,000 labor hours per month. Therefore:

$$p1 + 3p2 \leq 1{,}000$$

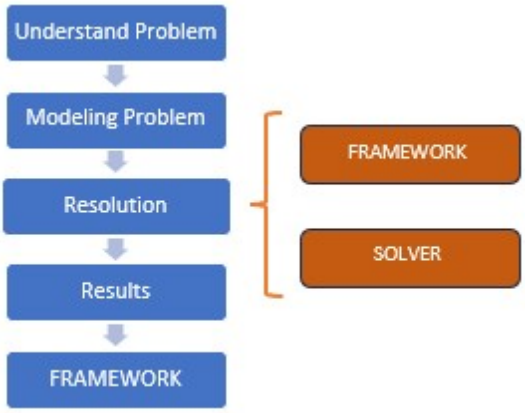
It is noteworthy that parameters are modeled based on the constraint of 1,000 labor hours.

SOLVING OPTIMIZATION PROBLEMS

The art of modeling and solving optimization problems. The essential part of developing a good program for resolving customers' problems is simply to fully understand their business process and understand the problem. The customer may not be aware of what the problem is, only what results they would like to see. Effective listening is therefore crucial to developing a model to determine if what the customer wants is *feasible* or non-feasible. We will return to discuss the concept of feasibility.

1. Must understand the business concept. Understanding the business process is crucial in order to determine all the variables, parameters, and ultimately the objective. Having a deep understanding of the business concept will the understanding of the problem, thereby revealing the constraints involved.

2. Model the process involves converting the business problem into a mathematical formulation. It will include parameters, variables, constraints, and solutions, feasible or non-feasible. The important thing to remember is the model is derived by the OR Analyst based on his/her interpretation of the business concept and problem, then interpreted into a mathematical interpretation.



3. Solve the problem.

   Solving the modeled algorithm can be done by hand if the problem is small, 2nd or 3rd-degree, however, it is not efficient, or slow, and changes in the variable values cannot be re-evaluated fluently. Most business problems are very complex and the use of modeling solvers will be needed. A programming environment will be needed, like Visual Studio, Jupiter Notebook, or Microsoft. Within the environment of the framework package or tool needs an associated solver that solves complex mathematical problems.

   - Φ Development environment. The development environment we will use is Visual Studio and Microsoft Excel.
   - Φ Framework is a package, tool to help model. The framework we will use is Julia which is an open-source program that is great at solving these types of models.
   - Φ A solver is an algorithm to solve mathematical problems. There are many solvers used depending on whether the problem is linear (LP), non-linear (NLP), mixed-complementarity (MCP), or other. Some of the solvers we will be using are Gurobi, Cbc, and CPLEX.

4. Print the results. The results will need a line output to the screen and possibly exported. An intentional print output will be required.

Another advantage of Julia is its ease of use. Julia's syntax is similar to that of other high-level programming languages, such as Python and MATLAB, which makes it easy for users to pick up quickly. The language is also highly extensible, with a vast library of packages that enable users to perform a wide range of tasks.

Next, we will start the process of modeling and programming the model into Julia. We will also look at some installation problems someone might encounter and tips.